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Late Potato Blight Epidemics in Iowa as Correlated with Climatic Conditions

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LATE POTATO BLIGHT EPIDEMICS IN IOWA AS CORRELATED WITH CLIMATIC CONDITIONS.

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At least three pronounced outbreaks of the late blight of the potato, *Phytophthora infestans,* have occurred in Iowa within the past forty-five years. These were in 1885[1], 1903, and 1915[2]. The northern limits of the region generally designated as the corn belt seems to represent in a general way the southern limits of this disease under normal climatic conditions. This is indicated by the fact of its frequent occurrence in the region just north of us.

From these regions of the north we receive our annual seed supply and this disease is therefore probably introduced into some portions of the state every year. The fact that under normal climatic conditions in Iowa it does not survive even when so introduced and yet in occasional years breaks forth in a virulent form, presents an interesting problem.

In many parts of the New England states late blight usually is an ever present disease and fails to develop only in dry years. In Iowa the conditions are reversed. It is normally absent and its presence in every known instance has been accompanied by abnormal weather conditions. This fact indicates an interrelationship between these outbreaks and the atmospheric conditions. In the following pages is presented a study of the correlations between climatic conditions and late blight epidemics in this state.

The relationship existing between many diseases and certain climatic factors is well known. It is usually difficult, however, to separate out the operative and nonoperative factors and to determine which are finally causative. The fact that in Iowa the outbreaks of this potato blight have always been accompanied by abnormal conditions permits of a careful study of its relation to those conditions and hence presents an approach to the

[1]The outbreak for 1885 was reported by Halsted, B. D. (Bot. Dept. Bull. Ia. Agrl. College, 95, Feb., 1888), and those for 1903 and 1915 came under the observations of the writer.

[2]Specimens for the years of 1903 and 1915 are filed in the Bot. Dept. herbarium of this institution and are identified by L. H. Pammel.

problem from a direction the reverse of that in the New England states, where considerable attention has been given to this disease.

Notable studies of late blight have been made under laboratory conditions, the most recent being those of Melhus[3]. These have contributed important information relative to the life history of the fungus and cleared away a number of erroneous conclusions based upon its supposed similarity to other mildews whose life histories were well known. Laboratory studies, however important, require confirmation under field conditions covering long periods of time and different sections of the country.

FIELD OBSERVATIONS IN IOWA.

In the following pages the writer has endeavored to supply these field data for Iowa conditions. It is particularly interesting to note the close parallelism between the actual conditions of the field and the findings of the laboratory, a fact which emphasizes the value of laboratory investigations for the correct interpretation of field data.

MOISTURE SUPPLY.

One of the vital factors affecting the growth of diseases is moisture supply. When present in excessive quantities, the plant growth is apt to be very succulent and sappy thus affording ideal feeding grounds for the parasite and these conditions also augment spore production.

The rainfall by months for the years of 1885, 1903, and 1915, is presented in the following table:

RAINFALL FOR IOWA.

YEAR	JUNE	JULY	AUGUST	TOTAL DEPARTURE FROM NORMAL	TOTAL PERCENTAGE EXCESS
Normal	4.38 in.	3.92 in.	2.91 in.		
1885	5.03 in.	6.55 in.	6.10 in.	—6.47 in.	52.05
1903	2.86 in.	4.83 in.	6.64 in.	—2.84 in.	22.85
1915	4.16 in.	8.32 in.	2.81 in.	—3.27 in.	26.30

It will be noted that the rainfall was deficient for June in two of these years. July and August were very wet for 1885,

[3]Melhus, I. E., Jour. Agrl. Res. V—2, Oct., 1915.

the total excess for the three months being 52 per cent. July and August of 1903 were also wet, the total excess amounting to 23 per cent.

July of 1915 was very wet, in fact with one exception the wettest July in the climatological history of the state. August of 1915 was dry but the total excess of rainfall for the three months was approximately 26 per cent.

Since there is a vital relationship between weather conditions covering the period of incubation and since that period also bears a direct relationship to the time of final outbreak or secondary period of infection, we have presented the rainfall data in the following table in ten-day periods which we shall call decades.

RAINFALL FOR SUMMER MONTHS OF 1903 BY DECADES IN INCHES.

(*Des Moines Station.*)

	ACTUAL	NORMAL	DEPARTURE
JUNE:			
First decade	.59	1.67	—1.08
Second decade	1.56	1.72	— .16
Third decade	.91	1.57	— .66
JULY:			
First decade	1.57	1.24	— .33
Second decade	.32	1.31	— .99
Third decade	1.73	1.31	— .42
AUGUST:			
First decade	2.63	1.00	—1.63
Second decade	.23	1.48	—1.25
Third decade	3.86	1.13	—2.73
Total.....	13.40	12.43	— .97

In two instances, the first decade of June was wet and in one dry. The second decade of June in two of the years was dry and wet in one. The third decade of all three Junes was dry. These conditions point to the fact that an excess of moisture in June is not a requisite factor for the development of this disease and that even a normal June moisture supply is not necessary. In brief, the moisture supply for June would not seem to be a limiting factor for the development of late blight under Iowa conditions.

July for all three decades of the three years was with one exception wet. The third decade of July was in all instances

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very wet. The excess in two of them was quite pronounced. The conditions in this third decade of July are without doubt significant in relation to the outbreaks which occurred during this period in at least two of the epidemics. The decade in which the outbreak of 1885 occurred was not recorded, but judging from analagous climatic conditions it also occurred probably during the third decade of July and during early August.

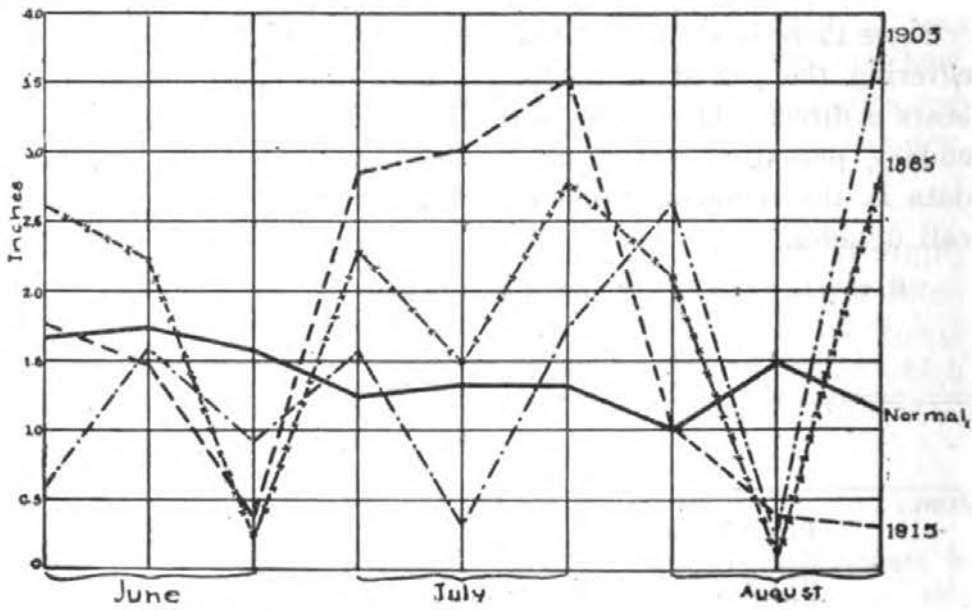

FIG. 49—Rainfall by decades of each month. Des Moines station.

The first decade of August was wet in all three years. This third of the month was also covered in at least two of these outbreaks by a period of secondary infection. The second decade of August was dry in all three instances. Since the vines were dead by this time, the atmospheric conditions for the second and third decade of August would not be significant in relation to foliage destruction.

HUMIDITY.

Humidity and rainfall are usually closely associated though such is not necessarily the case. From the standpoint of the host plant, rainfall is the more important factor while humidity bears a direct relationship to the growth and development of foliage diseases. A liberal supply of atmospheric vapor and dew combined with the right degree of temperature provides ideal conditions for spore production and germination. In the following table are presented the humidity data for the three years in question.

HUMIDITY TABLE.

(*Des Moines Station.*)

	JUNE PER CENT	JULY PER CENT	AUGUST PER CENT	TOTAL PERCENTAGE DEPARTURE FROM NORMAL
Normal	68.0	67.6	71.4	
1885	76.6	79.8	79.7	—29.1
1903	71.1	72.2	78.0	—14.3
1915	74.0	71.1	75.4	—19.5

It will be noted from this table that the humidity factor is much more constant than that of rainfall. In all of the months in all three years, the humidity runs abnormally high even in the months in which the rainfall was deficient.

The conditions with regard to humidity are more clearly brought out in relation to the different stages of the development of the disease when presented by decades.

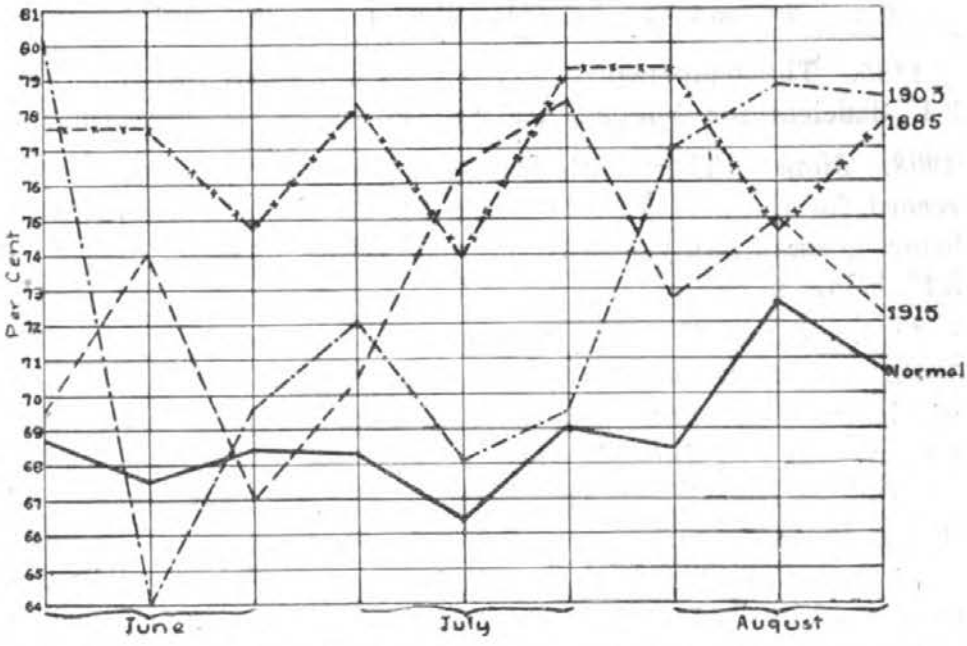

FIG. 50—Per cent of humidity by decades of each month. Des Moines station.

Without reviewing the decades of each month in detail, special attention is called to the high degree of humidity for the third decade of July in 1885 and 1915. For the year 1903, this high stage of humidity came a little later and was reached during the first decade of August.

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TEMPERATURE.

Probably but few parasitic fungi are more sensitive to temperature conditions than late blight. Its occurrence in Iowa is dependent upon comparatively cool weather and in the cool climate of Maine upon comparatively warm weather. In both instances the thermal mean for the years of its recurrence is probably much the same. In one territory, its growth is limited by too low a normal and in the other by one too high.

The mean temperature in Iowa by months is given in the table below:

MEAN TEMPERATURES FOR IOWA.

	JUNE DEGREES F.	JULY DEGREES F.	AUGUST DEGREES F.	TOTAL DEPARTURE DEGREES F.	TOTAL PERCENTAGE DEPARTURE
Normal	69.1	74.1	71.8		
1885	69.0	75.9	68.7	—1.4	.65
1903	64.6	70.9	69.1	10.7	4.83
1915	65.1	69.5	65.9	14.5	6.74

1885. The temperature was .1° below normal for June and 3.1° deficient for August. July averaged 1.8° above normal.

1903. June—"The month just closed was the coldest June on record for the period of 14[4] years." The daily mean was 5.6° below normal. July—Daily mean 2° below normal. August—3.1° below normal.

1915. June—4° below normal. "The coldest June since 1903. At numerous stations the monthly mean and absolute maximum temperature for the month was lower than ever before recorded in June." July—"With one exception the coldest July of record." "August, 1915, was the coolest month of that name in the climatological history of the state. The monthly mean temperature and the monthly extremes were all lower than was ever before recorded and the daily means were below the normal means on all but four or five days during the month." Frost occurred in some part of Iowa in every month of the year 1915.

Taken as a whole, the years of outbreaks were distinctly cool seasons. Subnormal temperatures were very pronounced for

[4]The climatological data of this bulletin are based upon the records of the Iowa Weather Bureau. Thanks are due the director, G. M. Chappel.

the summers of 1903 and 1915. The same is true for 1885 with the exception of the third decade of July. During this decade the humidity, however, was above normal and gave one of the highest readings on record.

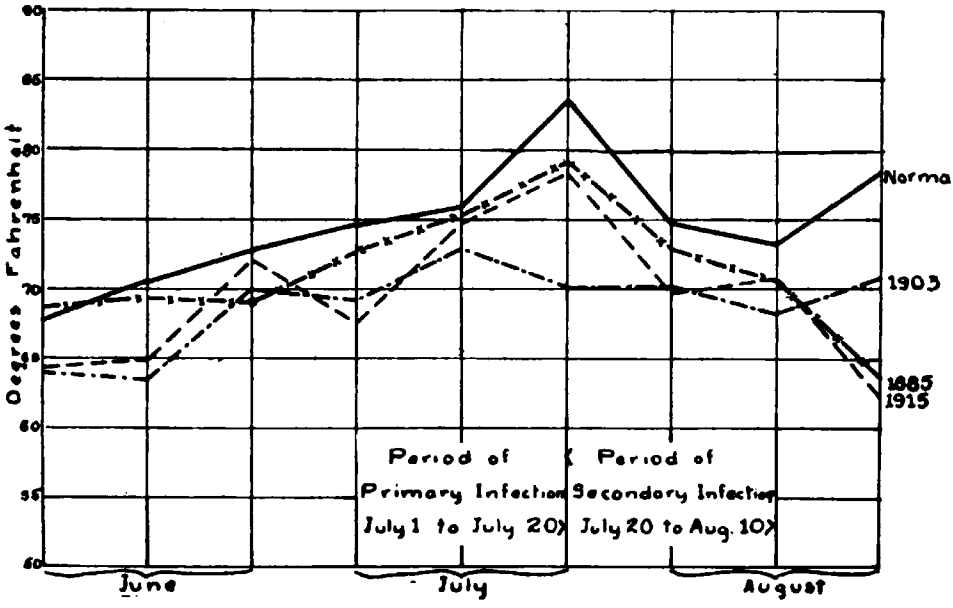

FIG. 51—Mean temperature by decades of each month. Des Moines station.

The deduction is clear that the normal mean temperatures for the summer months are too high for the development of late blight in Iowa and are limiting factors.

The exact optimum between the upper and lower temperatures at which this disease thrives under field conditions is difficult to determine. Selby[5] in laboratory tests found that temperatures ranging from 65° Fahrenheit to 75° Fahrenheit produced favorable conditions for the disease and Galloway states that "A normal temperature of from 72° Fahrenheit to 74° Fahrenheit accompanied for any considerable time by moist weather furnishes the best conditions for the spread of the disease."

Since the normal mean in Iowa for July is 74.1° Fahrenheit and for August 71.8° Fahrenheit and as the disease has occurred here only in the seasons of subnormal temperature during these months, it would seem that the last named figures are perhaps high.

[5]Selby, A. D., Ohio Naturalist, Feb., 1907.

The average of the means for July and August for the three years in question is 70° Fahrenheit. This temperature would seem to represent the danger line. So far as the temperature conditions are a factor, a mean below 70° Fahrenheit for the latter part of July and early August provides favorable conditions for an outbreak of late blight. In this connection it is interesting to note the statement made by Smith[6] that "The critical districts (for late blight) would be along the line of 70° Fahrenheit."

Conversely, regions lying within a mean above 70°, which includes Iowa, would be but little affected. The study of its history in this state supports this conclusion.

Since the disease is always more or less present through the introduction of infected seed, there is always the probability of an outbreak at a mean temperature below 70° Fahrenheit provided the humidity factor is also favorable.

SOIL TEMPERATURES.

The initial growth of the mycelium in an infected tuber is probably largely a matter of temperature conditions as moisture is supplied directly by the tuber.

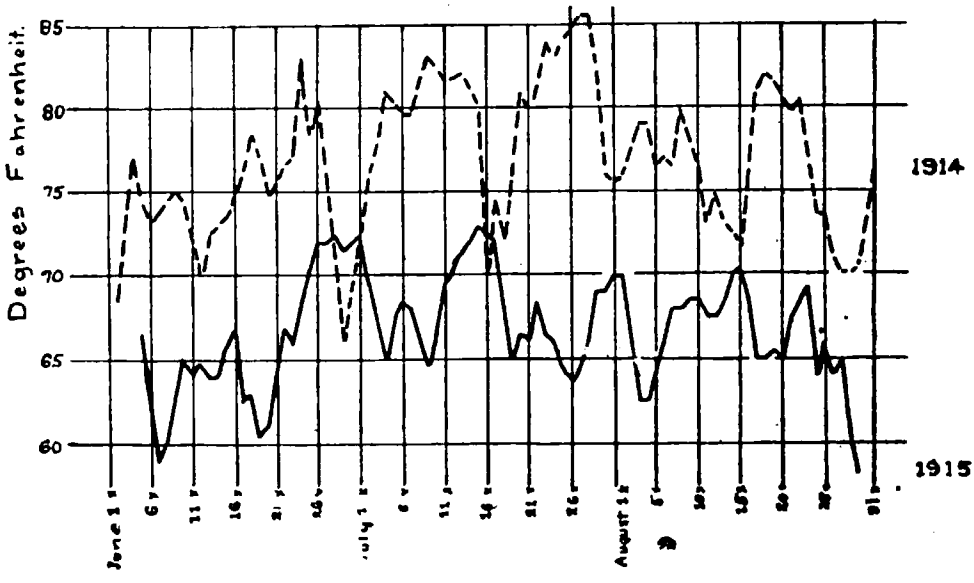

FIG. 52—Mean soil temperatures, Ames, Iowa. Readings taken at a depth of six inches.

The soil temperatures for the season of 1915 in comparison with those for 1914 are presented in the following table.

[6] Smith, J. W., Monthly Weather Review, 43-5-234, May, 1915.

These readings were taken in the experiment station potato field at a depth of six inches, which probably represents the main zone of tuber development for the potato. It will be noted that soil temperatures for 1915 are strikingly low as compared with 1914. It is to be regretted that this comparison cannot be made with a normal established over a long period of years. Orton[7] reports that in the outbreak of 1893 in Pennsylvania, the soil temperatures for the summer were notably low, and suggests that the soil temperatures are probably the prinary factor in developing an epidemic. It is readily conceivable that the soil temperature is a limiting factor in the initial growth of the mycelium. However, once it reaches the foliage and sporulation begins the controlling factors would seem to be atmospheric rather than those of the soil. In fact, the study of our field conditions leads to the suggestion that through the planting of new seed the disease frequently makes a start but fails to sporulate due to unfavorable atmospheric conditions. Being unable to propagate it quickly perishes.

Through the courtesy of Professor J. G. Mosier of the Illinois Experiment Station we have the soil temperature records for the year 1915 in comparison with a normal, covering a ten year period at that station.

SOIL TEMPERATURES AT A DEPTH OF THREE INCHES.

(Champaign, Illinois.)

1915	ACTUAL DEGREES F.	NORMAL DEGREES F.	DEGREE DEPARTURE	PERCENTAGE DEPARTURE
June	71.13	72.00	— .87	—1.21
July	74.06	75.80	— .74	— .98
August	70.23	75.80	—4.57	—6.03

In the following Sunshine Chart is shown the percentage of possible amount of sunshine for the years 1903 and 1915 as compared with the normal.

[7]Orton, C. R., Contributions from Dept. Bot. Pa. St. Coll., 1916.

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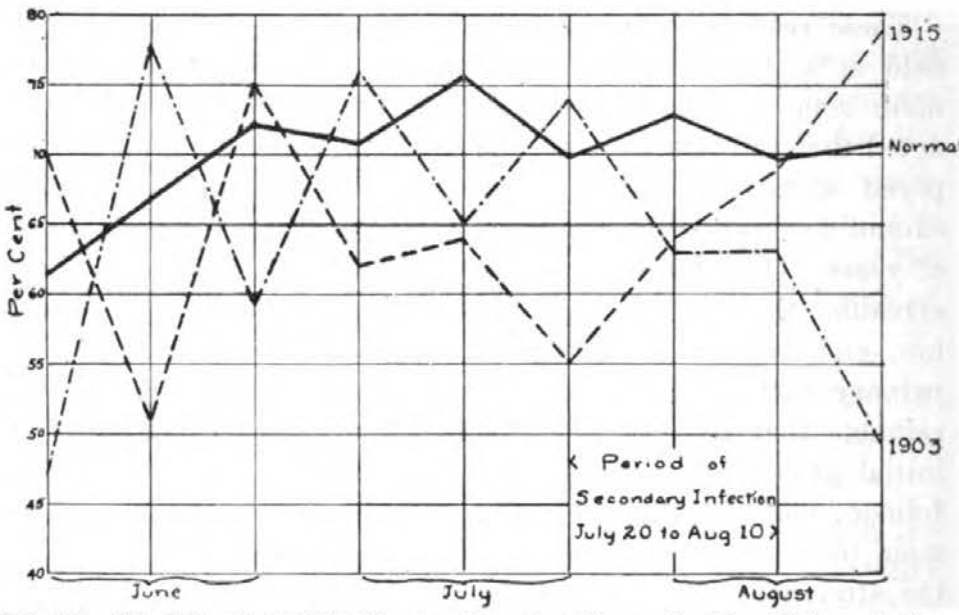

FIG. 53—Per cent of sunshine by decades of each month. Des Moines station.

Particular attention is called to the period covering the third decade of July and the first decade of August of this table in its relation to the period of secondary infection.

Unfortunately the sunshine records for 1885 are not available as they were not taken in this form by the Weather Bureau at that time.

As expressed in terms of clear, partly cloudy and cloudy days, the record for 1885 was as follows:

	CLEAR	PARTLY CLOUDY	CLOUDY
June	4	21	5
July	5	15	11
August	11	11	9

The germicidal properties of sunshine are well known. The delicate thin walled conidia are quickly destroyed by exposure to bright sunshine. The predominance of cloudy days was therefore an important aid in the propagation of the disease.

SUMMARY.

Climatic conditions in Iowa are generally unfavorable to the development of *Phytophthora infestans.*

The seasons in which it did occur were characterized by subnormal temperatures, high humidity, heavy dews, excessive rainfall and a predominance of cloudy weather.